sus·pen·sion (sə spen′shən) *n.* [ML. *suspensio* < LL., an arching < L. *suspensus:* see SUSPENSE] 1. a suspending or being suspended; specif., *a*) a temporary barring from an office, school, etc. *b*) a temporary stoppage of payment, service, etc. *c*) a temporary canceling, as of rules *d*) a deferring of action on a sentence *e*) a holding back of a judgment, etc. 2. a supporting device or framework upon or from which something is suspended 3. the system of springs, etc. supporting a vehicle upon its undercarriage or axles 4. the act or means of suspending the balance or pendulum in a timepiece 5. *Chem.* *a*) the condition of a substance whose particles are dispersed through a fluid but not dissolved in it *b*) a substance in this condition *c*) a mixture of tiny, solid particles suspended in a liquid in such a way that the particles will separate out on standing: cf. COLLOID 6. *Music* *a*) the continuing of one or more tones of one chord into a following chord while the others are changed, so that a temporary dissonance is created *b*) the tone or tones so continued

suspension bridge a bridge suspended from chains or cables which are anchored at either end and supported by towers at regular intervals

SUSPENSION BRIDGE

suspension point any of a series of dots, properly three, indicating the omission of a word, phrase, sentence, etc., as from something quoted

sus·pen·sive (sə spen′siv) *adj.* [ML. *suspensivus*] 1. that suspends, defers, or temporarily stops something 2. tending to suspend judgment; undecided 3. of, characterized by, expressing, or in suspense 4. [Rare] of or characterized by physical suspension —**sus·pen′sive·ly** *adv.*

sus·pen·soid (-soid) *n.* [SUSPENS(ION) + (COLL)OID] a system of solid, colloidal particles suspended in a liquid

sus·pen·sor (-sər) *n.* [ML.] 1. *same as* SUSPENSORY 2. *Bot.* a cell or group of cells that forces the embryo of a higher plant into its food supply, the endosperm

sus·pen·so·ry (-sə rē) *adj.* [< L. *suspensus* (see SUSPENSE) + -ORY] 1. suspending, supporting, or sustaining [a *suspensory* muscle or bandage] 2. suspending or delaying, esp. so as to leave something undecided —*n., pl.* **-ries** 1. a suspensory muscle or bandage 2. a mesh fabric pouch for supporting the scrotum, held by a band around the hips

suspensory ligament any of various ligaments supporting body organs; esp., a ligament supporting the lens of the eye

p 1434

The Golden Gate Bridge is one of the world's longest suspension bridges. It has a main span of 4,200 feet (1,280 meters) and a total length of 8,981 feet (2,737 meters). The bridge spans a channel of San Francisco Bay and links San Francisco with Marin County, California.

BRIDGE is a structure used by people and vehicles to cross areas that are obstacles to travel. Engineers build bridges over lakes, rivers, canyons, and dangerous highways and railroad tracks. Without bridges, people would need boats to cross waterways and would have to travel around such obstacles as canyons and ravines.

Bridges range in length from a few feet or meters to several miles or kilometers. A bridge must be strong enough to support its own weight as well as the weight of the people and vehicles that use it. The structure also must resist various natural occurrences, including earthquakes, strong winds, and changes in temperature.

Most modern bridges have a concrete, steel, or wood framework and an asphalt or concrete *roadway*. The roadway is the part of a bridge on which people and vehicles travel.

The majority of bridges are held up by at least two supports that are set in the ground. The distance between two adjacent supports is called a *span* of a bridge. The supports at each end of the bridge are called *abutments*, and the supports that stand between the abutments are called *piers*. The total length of the bridge is the distance between the abutments. Most short bridges are supported only by abutments and are called *single-span bridges*. Bridges that have one or more piers in addition to the abutments are called *multi-span bridges*. Most long bridges are multi-span bridges. The *main span* is the longest span of a multi-span bridge.

A *pontoon bridge* has no piers or abutments. It is supported by *pontoons* (flat-bottomed boats) or other portable floats. See PONTOON BRIDGE.

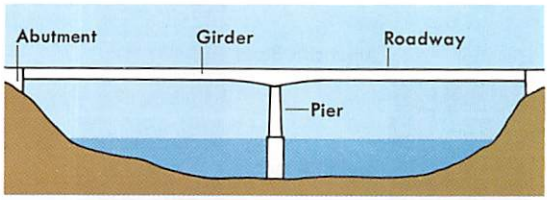
Fred F. Videon, the contributor of this article, is Professor of Civil Engineering at Montana State University. The diagrams in the article were prepared for WORLD BOOK *by Richard Fickle.*

Kinds of Bridges

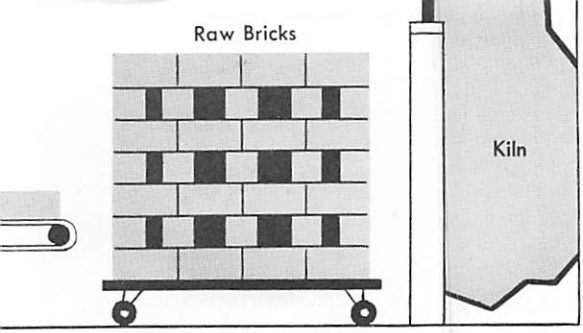
There are seven main kinds of bridges: (1) girder bridges, (2) truss bridges, (3) arch bridges, (4) cantilever bridges, (5) suspension bridges, (6) cable-stayed bridges, and (7) drawbridges.

The types of bridges vary in total length, the length of their spans, and the weight they can support. Before deciding which kind to build at a particular place, engineers determine the length of the structure and of each span. They also must consider the maximum load that the bridge will carry and the materials available to construct the bridge.

Girder Bridges, which include many highway bridges, are made of beams called *girders* whose ends simply rest on piers or abutments. These bridges may be used to cross most areas. The span length of girder



Girder Bridge



cost more. Builders find them suitable for swimming pools and other places where wall tile might be used.

Sizes. At one time, bricks were made in various sizes and shapes, depending on the locality in which they were made. In the United States the standard size for common brick is $2\frac{1}{4}$ inches (5.7 centimeters) thick, $3\frac{3}{4}$ inches (9.5 centimeters) wide, and 8 inches (20 centimeters) long. Bricks cast to specified sizes and shapes are called *molded bricks* and are used for ornamental purposes, such as window trim, moldings, arches, and chimneys.

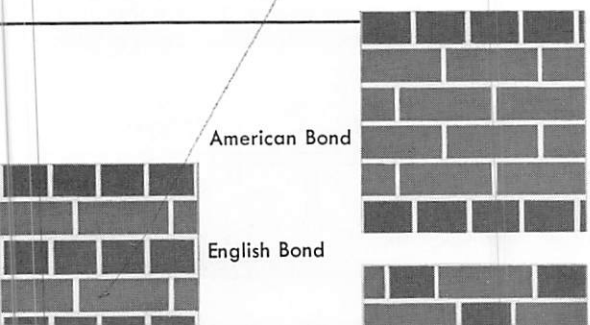
Bricklaying

Bricks usually are laid on their flat sides to form *courses* (horizontal layers) separated by *mortar joints* from $\frac{1}{8}$ to $\frac{1}{2}$ inch (3 to 13 millimeters) thick. A *bricklayer*, who puts the bricks in place, is assisted by a *hod carrier*, who delivers bricks and mortar to the bricklayer. The construction formed is called *brickwork* or *brick masonry*.

Bonding. Bricks are arranged so that they lap over each other to stagger the vertical joints. Thus, it is possible to distribute loads over a large area. The various arrangements are called *bonds*. Bricks laid with the ends exposed are called *headers*. Those laid with the sides exposed are called *stretchers*. The various bonds consist of different arrangements of headers and stretchers.

In *running bond* (*stretcher bond*), all the bricks are stretchers. *Common bond* (*American bond*) consists of four to six stretcher layers between single header layers. *English bond* consists of alternate courses of headers and stretchers. The joints in alternate courses line up vertically. In *Flemish bond*, each course consists of alternate headers and stretchers, with the headers centered on the stretchers of the courses above and below.

Mortar is used between bricks to form joints. The mortar secures an even bearing, holds the bricks in position, and makes a tight wall. The mortar usually contains portland cement for strength, hydrated lime for workability, sand for economy and volume, and water for workability and the necessary chemical reactions. A commonly used mortar consists of one part portland cement, one part hydrated lime, six parts sand, and enough water to make the mixture soft and workable. See CEMENT AND CONCRETE.



Preserving Brick

Brick construction will last hundreds of years if satisfactory materials and construction methods have been used. The brick also must be cared for properly. Weather will wear away the mortar from the joints and they should be repaired periodically. An unsightly whitish discoloration, known as *efflorescence*, sometimes appears on the brick. Efflorescence results when salts from within the brick and mortar are carried to the surface by water. The water evaporates, but the salts remain and cause the brick to chip and crumble. The deposits can be removed by scrubbing with diluted hydrochloric acid solution, then rinsing with plain water.

History

Brick is the oldest manufactured building material. Sun-dried brick was used in the Middle East by 6000 B.C. The chief occupation of the Israelites during their captivity in Egypt was making sun-dried brick from clay taken from the Nile River. In the United States, bricks were made in Virginia as early as 1612. Until the 1900's, brick was used to pave streets and sidewalks, and to build chimneys for industrial plants. But bricks have largely been replaced by concrete and asphalt for paving, and by steel for chimneys. GEORGE W. WASHA

See also ADOBE; BUILDING TRADE; CLAY.

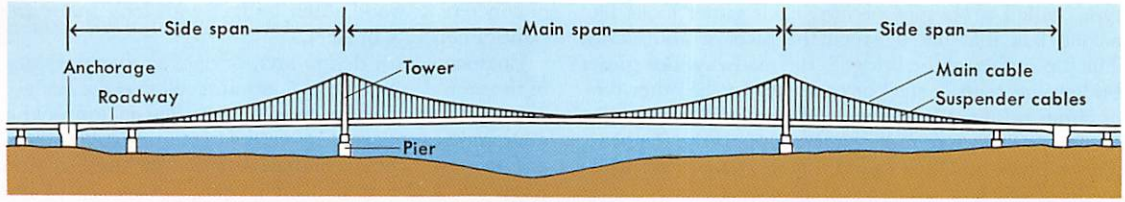
BRICKER, JOHN WILLIAM (1893-), was the Republican candidate for vice-president of the United States in 1944. He and presidential candidate Thomas E. Dewey were defeated by President Franklin D. Roosevelt and Harry S. Truman. Bricker served as governor of Ohio from 1939 to 1945. He was elected to the United States Senate in 1946, and was reelected in 1952. Bricker was born in Madison County, Ohio. He received a bachelor's degree and a law degree from Ohio State University. JAMES H. RODABAUGH

BRIDAL WREATH is a shrub that belongs to the rose family. It is found in temperate regions and grows about 6 feet (1.8 meters) high. It has slender, curving branches and dark green leaves that turn orange in autumn. The leaves are smooth and oblong and may have cut edges. The flowers bloom in April and May. These white flowers are about $\frac{1}{3}$ inch (8.5 millimeters) across and grow in clusters. See also ROSE; SPIRAEA.

Scientific Classification. Bridal wreath is in the rose family, *Rosaceae*. It is classified as genus *Spiraea*, species *S. prunifolia*. J. J. LEVISON

BRIDALVEIL FALL is one of the most beautiful sights of Yosemite National Park, Calif. The fall drops a misty curtain of water from a height of 620 feet (189 meters) of colorful rock. Sometimes the wind strikes the fall in such a way as to send sprays of water back over the cliff from which it fell. Then the fall seems like the veil of a bride. See also CALIFORNIA (picture).

BRIDE, SAINT. See BRIDGET, SAINT.



Suspension Bridge

Suspension bridges are used to span great distances. Most suspension bridges have a main span more than 1,000 feet (300 meters) long. Some have a main span longer than 4,000 feet (1,200 meters). Suspension bridges also are used to cross deep water or steep canyons, and in other places where the construction of piers is especially difficult and expensive. These bridges require only two piers, each of which supports a tower.

The main span of a suspension bridge stretches between the two towers. Each of two *side spans* extends between a tower and an *anchorage*. Most anchorages are huge blocks of concrete set at the ends of the bridge.

The cables that are supported by the towers are called the *main cables*. A suspension bridge has at least two main cables. Each of these cables extends from one end of the bridge to the other and is secured at each end by an anchorage. The main cables are connected to the top end of vertical *suspender cables*. The bottom end of each suspender cable attaches to the roadway of the bridge.

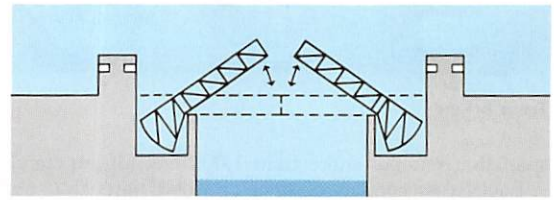
A suspension bridge may sway in a strong wind. To minimize such movement, most suspension bridges have a thick structure that supports the roadway. This type of structure helps stiffen the bridge and is called a *stiffening girder* or *stiffening truss*.

Cable-Stayed Bridges resemble suspension bridges. Both have roadways that hang from cables, and both have towers. In a cable-stayed bridge, however, the cables that support the roadway are connected directly to the towers.

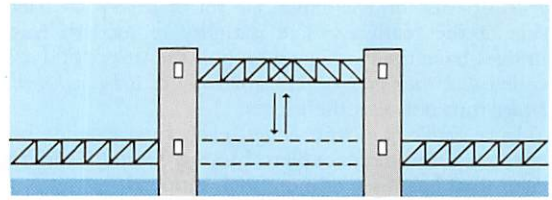
A cable-stayed bridge may be used if its foundation can support only one tower. Most cable-stayed bridges have three spans, but some have one tower and two spans. The most efficient cable-stayed bridges have a main span about 700 feet (210 meters) long.

The cables of a cable-stayed bridge may be linked from the roadway to the towers in several ways. The cables may extend from various points on the roadway to the tops of the towers, forming a *radiating pattern*. The cables form a *fan pattern*, also called a *harp pattern*, if they are connected from a variety of points on the roadway to several points on the towers. If the cables are attached from one point on the roadway to various points on the towers, they form a *star pattern*.

Drawbridges have a roadway that is moved entirely or partially to provide enough clearance for large ships to pass. There are three types of drawbridges, *bascule bridges*, *lift bridges*, and *swing bridges*. A bascule bridge tilts upward to open. Some bascule bridges open at one end, and others open in the middle. A lift bridge has a roadway that extends between two towers. The roadway rises between the towers, and ships pass underneath. A swing bridge is mounted on a central pier. The bridge swings sideways to enable ships to pass.



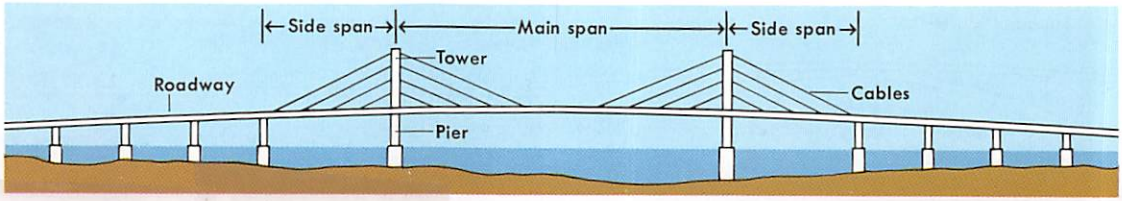
Bascule Bridge



Lift Bridge

History

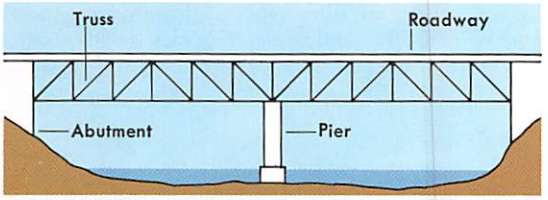
Logs or vines that extended across streams probably served as the first bridges. The first bridge known to



bridges ranges up to about 700 feet (210 meters).

There are two main types of girder bridges. In one type, called a *box girder bridge*, each girder looks like a long box that lies between the piers or abutments. The top surface of the bridge is the roadway. Box girder bridges are built of steel or concrete. In the other type of girder bridge, the end view of each girder looks like an *I* or a *T*. Two or more girders support the roadway. This type of bridge is called a *plate girder bridge* when made of steel, a *reinforced* or *prestressed concrete girder bridge* when made of concrete, and a *wood girder bridge* when made of wood.

Truss Bridges are supported by frameworks called *trusses*. The parts of the trusses are arranged in the form of triangles. Such bridges are built over canyons, rivers, and other areas. A truss bridge may have a main span that extends more than 1,000 feet (300 meters).



Truss Bridge

Each truss consists of steel or wood parts that are connected to form one or more triangles. The simplest truss consists of three parts fastened together at their ends to form a triangle.

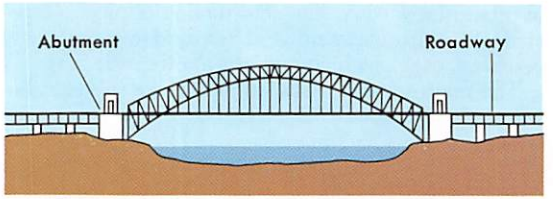
Most truss bridges have one set of trusses on each side of the roadway. The majority of modern truss bridges have the roadway on top of the trusses and are called *deck truss bridges*. The roadway of a *through truss bridge* runs between the trusses.

In a *simple span truss bridge*, each truss extends between two abutments or piers. In a *continuous truss bridge*, each truss has three or more such supports.

Some locations are suitable for either a truss bridge or a girder bridge. In such cases, some engineers choose to build a truss bridge because it requires less construction material than the girder type. However, many engineers prefer a girder bridge because it is more attractive, and it is easier to construct and maintain.

Arch Bridges are structures in which each span forms an arch. The spans range up to about 1,700 feet (518 meters) long. The arch bridge is one of the oldest types of bridges. Early arch bridges consisted of large stone blocks wedged together to form an arch. Today, the majority of arch bridges that have short spans are made of concrete or wood. Arch bridges with long spans are built of concrete or steel.

Engineers must design arch bridges so that the sides of the arch do not spread apart and collapse the bridge. The roadway of some arch bridges lies on top of the arch and is supported by vertical columns called *spandrel columns*. These columns transfer the load of the roadway to the arch, which bears the weight of the bridge. The roadway of a *tied arch bridge* is below the curve of the arch. The roadway is supported by girders or other types of beams that hang from the arch. The girders or beams also connect to the ends of the arch to prevent the ends from spreading out. The abutments support the weight of the bridge.



Steel Arch Bridge

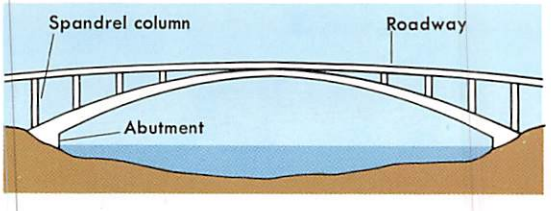
Cantilever Bridges consist of two independent beams called *cantilevers* that extend from opposite banks of a waterway. The two cantilevers are joined together above the middle of the waterway by a beam, girder, or truss. Cantilever bridges may have spans as long as about 1,800 feet (549 meters).

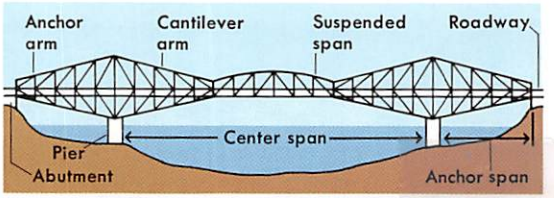
Each cantilever has two sections, an *anchor arm* and a *cantilever arm*. The anchor arm extends between an abutment and a pier. One end of the cantilever arm is supported by the pier, and the other end extends freely over the waterway. The free ends of the two cantilevers are joined together by a *suspended span*.

Most cantilever bridges have two *anchor spans* and one *center span*. Each anchor span consists of an anchor arm. The suspended span and the two cantilever arms make up the center span.

Many cantilever bridges have truss frameworks. Most bridges of the cantilever type are made of steel or prestressed concrete (see CEMENT AND CONCRETE [Prestressed Concrete]).

Suspension Bridges are perhaps the most impressive type of bridge because of their long main span and especially attractive appearance. These bridges have a roadway that hangs from steel cables that are supported by two high towers.





The city of San Francisco is viewed from across the San Francisco-Oakland Bay Bridge. The bridge became the **scene of a near-catastrophe during the 1989 earthquake that rocked the area.** (ZEFA)